Hermetic, Bioinert Ultrananocrystalline Diamond Coatings to Enable a Retina Prosthesis

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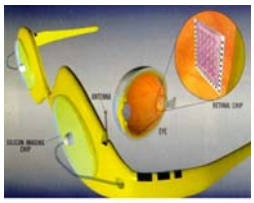
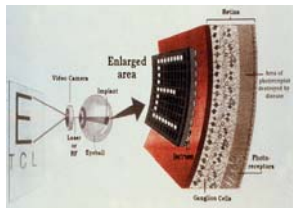
Motivation/Impact

- **UNCD enables a whole new generation of biomedical devices implantable in the human body**
  - **Develop hermetic and biocompatible UNCD thin films as encapsulation coatings for artificial retina microchip to enable implantation of Si microchip on human retina to restore sight to people blinded by retina degeneration**



Overall concept of Retinal Prosthesis for sight restoration to people blinded by retinitis picmentosa and macular degeneration



Functional Principle of Retinal Prosthesis

74 year old man see and recognizes objects after 55 years of total blindness

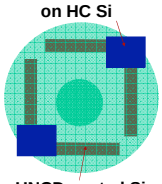
(six persons currently on clinical trials)

Major Accomplishments

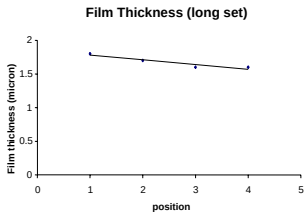
- **UNCD films are synthesized using plasma chemical vapor deposition involving a unique Ar-rich/CH_4 chemistry that produces films with 2-5 nm grains and 0.5 nm wide GB.**
- **UNCD films thickness and bonding uniformity across the surface are optimized by controlling the geometry of substrate location on the substrate holder in the PECVD system, growth time, substrate bias, and/or surface treatment.**

Geometrical arrangement of samples in PECVD system

Si cover to enable electrical contact on HC Si

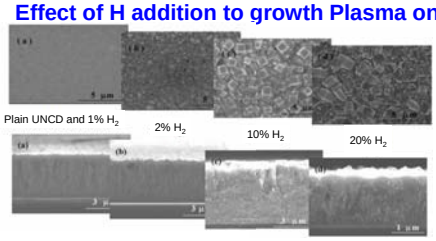


UNCD coated Si samples



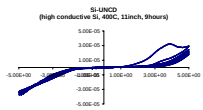
New geometrical arrangement produces UNCD films with improved thickness uniformity

Effect of H addition to growth Plasma on the structure of UNCD coatings

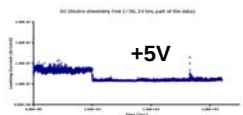


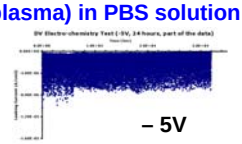
Hydrogen incorporation into GB satisfy dangling bonds resulting in reduction of leakage current in electro-chemical environment such as eye saline solution

Electrochemical test on UNCD coatings (1% H_2 in plasma) in PBS solution



Leakage current test in saline solution

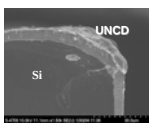


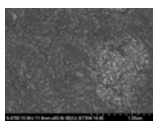


I_i vs V curves for mid-term tests at +5V and – 5V

SEM, XPS and AFM analysis of UNCD surface implanted in rabbit eye

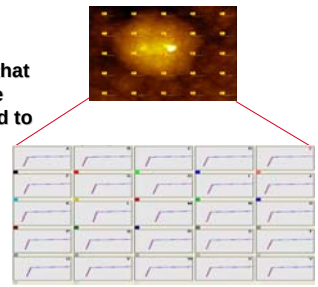
SEM picture of UNCD-coated Si chip showing excellent conformal/ hermetic UNCD coating



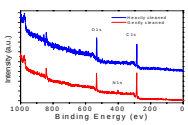


SEM picture of UNCD-coated Si chip after 6 months implantation in rabbit eye to test bioinertness

AFM force curves indicates that there is no soft matter on the surface of the UNCD exposed to rabbit eye

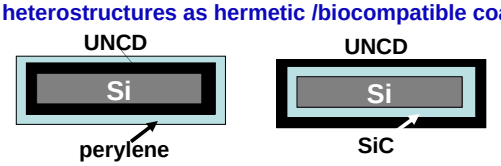


XPS analysis of UNCD surface exposed to rabbit eye environment Reveals no substantial chemical reactions



Future Work

- **Optimization of UNCD deposition process to achieve highest insulation and lowest leakage current**
  - **Explore UNCD/perylene and UNCD/SiC heterostructures as hermetic /biocompatible coatings**



- **Perform in vivo tests in rabbit eyes**

- **New research on oxide thin films for retina prosthesis**
  - **Commission and start operation of atomic layer deposition system to produce embedded capacitors for the**
  - **Perform fundamental and applied research to develop integrated coupling capacitors based on medium or high-dielectric constant thin films (preferable involving bioinert,biocompatible thin films) for input/output signal into microchip.**

X. Xiao, J. Wang, J. A. Carlisle, B. Mech, R. Greenberg, M. Humayun J. Weiland, and O. Auciello, J. of Biomedical Materials Research (2005).

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